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(54) CONDUCTOR FEED TROUGHS AND METHODS OF MAKING SAME

(71) We, UNITED STATES ATOMIC ENERGY COMMISSION, Washington, District of Columbia 20545, United States of America, a duly constituted agency of the Government of the United States of America established by the Atomic Energy Act of 1946 (Public law 585) and the Atomic Energy Act of 1954 (Public Law 703), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

High vacuum electron tubes, gaseous electrical discharge tubes and the like generally require some type or form of electrical "feed through" through an insulative material. Many of these tubes, particularly high voltage discharge tubes, utilize a ceramic material as the insulator, due to the good insulative characteristics of ceramic materials. It is difficult with ceramic materials to provide good vacuum or gas tight seal between the ceramic and the conductive, generally a metal wire or other member, feed through especially in those applications where the feed through seal may be subjected to a wide range of temperature environments either during manufacture or during actual use or storage. The integrity of the seal is often breached by these temperature variations due to the difference in coefficients of thermal expansion for the ceramic and the conductive material and the seal.

One typical method includes metalizing and plating two mating ceramic surfaces at the point at which the feed through is to be achieved. The two mating ceramic surfaces may then be brazed or otherwise permanently attached to the electrical feed through and to each other. During the brazing step, the ceramic surfaces often develop cracks which may cause loss of vacuum or gas and a resulting failure of the tube.

In light of the foregoing, it is an object of this invention to provide a method for forming a novel feed through conductor through a ceramic member.

It is a further object of this invention to provide a unitary ceramic member and electrical feed through.

Various other objects and advantages will appear from the following description of one embodiment of the invention, and the most novel features will be particularly pointed out hereinafter in connection with the appended claims. It will be understood that various changes in the details, materials, and arrangements of the parts, which are herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art.

The invention comprises intermixing a conductive material powder and insulative powder disposing an insulating powder about said intermixed powders to form the insulative base and sintering said insulative powder and said intermixed powders into a unitary structure. The invention further comprises the product resulting from this method.

The invention is illustrated in the accompanying drawings wherein:

Figs. 1(a) through 1(d) are diagrammatic cross-sectional view of a die apparatus showing different steps of the invention in the formation of a conductive feed through for an insulative member;

Fig. 2 is a perspective view in cross section of a completed conductive feed through and insulative member; and

Fig. 3 is a somewhat diagrammatic cross-sectional view of an electron tube utilizing conductive feed through devices similar to that shown in Fig. 2.

As shown, an insulative member having a conductive feed through in accordance with this invention is formed in a die body 10 as shown in Figs. 1(a) through 1(d). Die body 10 may be of any conventional shape and size having an internal cavity 12 with the desired shape and size for the finished insulative member. A support or base 14 is disposed within cavity 12 to provide an initial boundary for the insulative member. Base 14 may be

or form a part of the punch of a die press mechanism as described below. A plug 16 or other solid form having the desired shape of the finished conductive feed through and dimensions slightly in excess thereof is disposed on base 14 at the desired location of the feed through.

The insulative material of which the insulative member is to be made is poured or otherwise disposed within cavity 12 about plug 16 in the form of a powder. The insulative material powder may be any insulative material compatible with the environment in which it is to be used and which may be appropriately heated and/or pressed to form a unitary structural body. Typical insulative material powders include ceramics such as alumina, silica, magnesia, or mixtures thereof, glass and certain synthetic materials. It has been found that particularly good insulative material is 80% alumina with additions of talc and clay, both of which also may contain alumina, and additions of barium and calcium carbonates, so that the end combination may be nominally atbout 80% alumina. Such an insulative material mixture provides high structural strength, good insulating characteristics and high temperature stability.

The insulative material powder 18 may remain loosely distributed about plug 16 or it may be tamped or otherwise slightly packed to provide additional strength, depending upon the particular insulative material powder used. Plug 16 may then be removed leaving an opening or passageway 20 within, and preferably through, insulative material powder 18. Opening 20 may be formed without the use of plug 16 with insulative material powders having a sufficient cohesiveness to permit removal of a portion of powder 18 in the form of the opening 20 without collapsing and refilling the hole.

The blend or mixture of insulative material powders and conductive material powders may then be made by suitable hand or power mixing in a separate container. The insulative material powder may be the same as that used for insulative material 18 or it may be made of some other insulative material or mixtures thereof which exhibit a coefficient of thermal expansion the same as insulative material powders 18 or intermediate that and the coefficient of thermal expansion of the conductive material. The conductive material powder may be any conductive material which is compatible with the insulative material and the environmental conditions which the insulative member may be subjected. Suitable conductive material powders include such conductors as molybdenum, tungsten and chromium, and mixtures comprised of but not restricted to one or more of the following; manganese, titanium or titanium hydride with one or more of the aforementioned conductors. The additions are useful in modifying the expansion of the core ceramic and also bonding the conductor to the ceramic. It has been found that a particularly good conductive material comprises a mixture of about 80 parts by weight molybdenum, 20 parts by weight manganese and 15 parts by weight titanium hydride. This conductive powder mixture may be mixed with the appropriate insulative material powder with about 40 to 70% by weight insulative powder, such as about 60 percent by weight for the preferred insulative material powder described above.

Cavity or aperture 20 may then be filled with the insulative and conductive material powder mixture as shown by 22 in Fig. 1(c). To insure a good coefficient of thermal expansion gradient between insulative material 18 and the mixture 22, a portion of insulative material 18 and mixture 22 may be further blended at the interface thereof by any appropriate means such as by stirring with a small wire or by shaking or vibrating die body 10. Such additional blending will form an additional gradient of insulative material to conductive material between insulator material 18 and mixture 22 such as shown by 24 in Fig. 1d. There may be some applications where this interface 24 may be eliminated, such as in those instances where the coefficient of thermal expansion between insulative material 18 and mixture 22 is not significant over the temperature range which the materials may be subjected.

A die punch 26 may be placed within cavity 12 of die body 10 over the insulative material 18, interface 24 and mixture 22. Appropriate pressure, as illustrated by arrows 28 and 30 may be applied to the composite to press the powders together to establish a shape and a "green" strength for handling purposes. Suitable pressures may be varied from about 10,000 to about 30,000 psi. These pressures may be applied at room temperature or at an increased temperature depending upon the desired characteristics of the finished product.

The pressed composite may then be sintered at appropriate temperatures and in an appropriate atmosphere, such as in a wet hydrogen water saturated atmosphere, to achieve a near hundred percent dense body. The sintering may be carried out within die body 10 or the compressed composite may be removed from die body 10 and placed in a conventional furnace or the like. For the preferred insulative and conductive materials noted above, sintering temperatures may vary from about 1,450 to 1,510°C for periods of from about 30 to 50 minutes. The temperature and time ranges may be varied dependent on particular materials used and their characteristics.

The finished insulated member with conductive feed through is shown in Fig. 2. It will be readily apparent, that more than one feed through may be disposed within the insulative

member at any desired location thereof and that the insulative member may have any desired shape determined by the cavity shape of the die body 10. Also, the sintered composite member may be machined or lapped in a conventional member to achieve a thickness or other dimension required by a particular application. The feed through 22 may be formed first, either by suitable stacking or with an annular sleeve-type die, and the insulative powder then disposed thereabout before pressing and sintering or the feed through may be formed in an opening passing only part way through insulative material 18 and the sintered composite member machined to expose the feed through.

Fig. 3 illustrates a typical vacuum diode arrangement utilizing an annular ceramic body 40 with top and bottom ceramic members, each having conductive feed throughs 46, 48 and 50 respectively for the anode 52 and cathode 54. Feed throughs 46, 48 and 50 may have appropriate graded interfaces like interface 24, depending on the materials used. Anode 52 and cathode 54 and the necessary leads to the tube may be fastened to the appropriate feed throughs by brazing or welding or by a mechanical means such as a screw and threaded hole arrangement. The interface 56 and 58 between the respective ceramic parts of the tube may be metalized and brazed in a conventional manner to provide an appropriate seal or any other appropriate sealing arrangement may be used.

Feed throughs made in accordance with this invention have exhibited resistances as low as about .25 ohm with an about 1/8 inch thick ceramic. These feed throughs and interfaces provided thereby have been able to withstand temperature ranges of from about −150°F to 2000°F without loss of integrity or seal.

WHAT WE CLAIM IS:—

1. A method for forming a conductor in an insulative base comprising intermixing a conductive material powder and an insulative powder, disposing an insulative powder about said intermixed powders to form the insulative base and sintering said insulative powder and said intermixed powders into a unitary structure.

2. The method of claim 1 including of bending an interface between the boundary of said insulative powder and said intermixed powders.

3. The method of claim 1 wherein said sintering is at a temperature from 1,450°C to 1,510°C.

4. The method of claim 1 together with subjecting said insulative powder and said intermixed powders to pressures from 10,000 to 30,000 pounds per square inch before said sintering.

5. The method of claim 1 wherein said insulative powders are of the same insulative material.

6. The method of claim 5 wherein said insulative powder is a ceramic.

7. The method of claim 1 wherein said conductive material powder is a refractory metal.

8. The method of claim 1 together with providing an aperture in said insulative powder and disposing the intermixed powders in said aperture.

9. A method for forming a conductor in an insulative base as claimed in claim 1, substantially as hereinbefore described.

10. The product formed by a process as claimed in any preceding claim.

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1283287 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1a

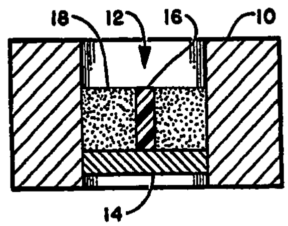

FIG. 1b

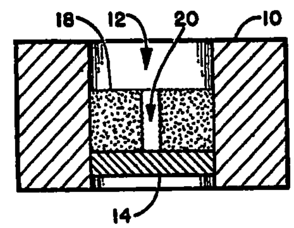

FIG. 1c

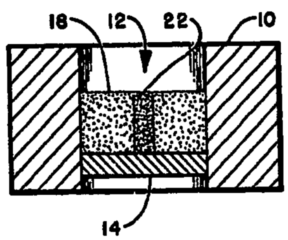

FIG. 1d

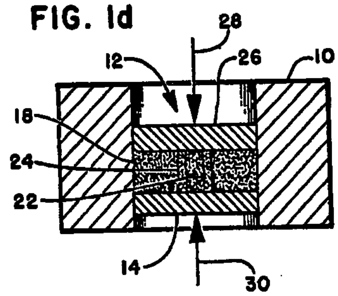

FIG. 3

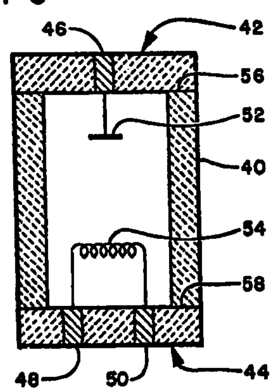

FIG. 2